Assessment of Streams in the Payette National Forest in 2000: Continued Monitoring of South Fork Salmon River Tributaries, Big Creek Tributaries Pre- and Post-fire Conditions

FINAL REPORT

Prepared For:

Payette National Forest
USDA Forest Service
McCall, Idaho

Prepared By:

Kathryn E. Bowman and G. Wayne Minshall

Stream Ecology Center
Department of Biological Sciences
Idaho State University
Pocatello, Idaho 83209

October 2001

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

This report presents the results of our research conducted for the Payette National Forest during 2000. As in previous years, our research was conducted on two groups of streams: (1) tributaries to Big Creek inside the Frank Church Wilderness Area and (2) tributaries to the South Fork of the Salmon River immediately west of the wilderness area. These streams have been variously influenced by wildfires since 1988 and 2000. The effect of wildfires on stream ecosystems has been the focus of our research over the past several years; however our efforts also are directed towards defining the range of natural variation in wilderness streams (see Royer et al. 1995, Royer and Minshall 1996).

Water chemistry displayed local effects in response to the 2000 fires. Pioneer Creek specific conductance increased between pre- and post-fire sampling dates, while Cougar Creek conductivity increased remained elevated between post-fire and post-runoff sampling dates. Alkalinity had essentially remained consistent over the three sampling periods except for in Cave Creek, in which it increased after the fire. Hardness values, on the other hand, substantially increased in the October sampling period (post-fire post-runoff). Periphyton chlorophyll *a* values for most streams increased after the fire and decreased in the scouring post-fire post-runoff sampling period. Values did not increase immediately after the fire however, by late September –early October values were substantially higher for almost all streams. Periphyton AFDM values followed the chlorophyll *a* trends.

Macroinvertebrate taxa richness ranged from 38 to 57 in the Big Creek tributaries and increased in all streams from 1999 to July 2000. Macroinvertebrate density ranged from 800-37,600 macroinvertebrates/m^2 in the Big Creek tributaries in 2000. From 1999 to 2000 most tributaries (all except Goat Creek) increased in macroinvertebrate biomass.

In the South Fork Salmon River watershed, although most streams decreased in alkalinity between 1999 and 2000, no long-term changes in water chemistry have been noted. Similarly, measurements of physical habitat characteristics have not displayed any consistent pattern over the course of the study. Overall, the physical and chemical habitat of the study streams has not been altered by the Chicken Fire.

Corresponding with the relative stability of the stream's physical and chemical habitat, the biotic components of the study also have not displayed any consistent patterns for evidence of fire effects on these streams. Periphyton has not shown any substantial changes in either chlorophyll-a or biomass/m^2. Because the habitat has not been altered substantially, it is not surprising that the benthic macroinvertebrate community metrics also have remained fairly consistent during the eleven-year study period. Macroinvertebrate density, biomass, species richness and Simpson's Index have also not been significantly affected by the Chicken Fire.

INTRODUCTION

This report summarizes the progress to date for data collected during 2000 from study streams in the Payette National Forest (Table1). Our initial research goal during 2000 was to continue monitoring tributaries to Big Creek inside the Frank Church Wilderness Area, which we have studied in previous years. These data have allowed us to examine the long-term influence of wildfire in structuring benthic habitat and invertebrate communities in the Payette National Forest (Royer and Minshall, 1996; Royer et. al, 1995) and to begin to document the range of natural variation of conditions found in Central Idaho streams, both burned and unburned. Several of these streams have been influenced by various wildfires since 1988. In 2000 we sampled in July, prior to the fires which burnt all of the tributary streams (to differing degrees) that we had previously studied, with the exception of Goat and Cougar Creeks. Subsequent sampling was conducted in September and October to encompass post-fire, pre-runoff, and post-fire/post-runoff conditions, respectively.

Tributaries to the South Fork of the Salmon River immediately west of the wilderness area were also sampled in 2000. Our studies in the S.F. Salmon catchment examine effects of the 1994 Chicken Fire. An additional component was added to the study in 1996: examining the effects of salvage logging on Big Flat Creek along the lower portion of the S.F. Salmon. Smith Creek, which is adjacent to the timber sale and serves as a reference for Big Flat Creek also was examined. Big Flat and Smith Creeks were sampled prior to the onset of the salvage logging, thereby providing a "pre-logging" data set for these sites.

Table 1. Location of the 2000 study streams in the Big Creek and South Fork of the Salmon River catchments.

Stream	Elevation (m)	Longitude	Latitude	UTM Position
Big Creek Catchment				
Rush Creek	1170	114^0 51.75' W	45^0 06.01' N	11 T 668172 4996302
Pioneer Creek	1165	114^0 51.03' W	45^0 05.98' N	11 T 669125 4996276
Cave Creek	1220	114^0 57.35' W	45^0 07.97' N	11 T 660740 4999745
Cliff Creek	1195	114^0 50.98' W	45^0 06.39' N	11 T 669171 4997032
Goat Creek	1125	114^0 48.46' W	45^0 06.53' N	11 T 672469 4997372
Cougar Creek	1095	114^0 49.30' W	45^0 06.29' N	11 T 671370 4996895
Big Creek	1150	114^0 50' W	45^0 06' N	
South Fork Salmon River Catchment				
Circle End Creek	1110	115^0 39' W	45^0 02' N	
Tailholt Creek	1110	115^0 39' W	45^0 02' N	
Fritser Creek	1036	115^0 38' W	45^0 05' N	
Smith Creek	914	115^0 31' W	45^0 14' N	
Big Flat Creek	914	115^0 33' W	45^0 13' N	

STUDY SITE DESCRIPTIONS

The study streams were located within the Payette National Forest in central Idaho either (1) along Big Creek in the Frank Church 'River of No Return' Wilderness Area or (2) along the South Fork of the Salmon River just outside the wilderness area (Table 1). In both catchments, the streams flow through steep valleys with forested slopes of primarily Douglas-Fir and Ponderosa Pine, also present are extensive bare or sparsely vegetated areas. Open areas of grass and sagebrush are common on the drier slopes in both catchments. The majority of the annual precipitation occurs as snow, resulting in peak flows from late spring through mid-summer. The streams generally remain at baseflow conditions from late summer through autumn.

Catchments of study streams in the Big Creek basin were influenced, to varying degrees, by either the Golden Fire of 1988 or the Rush Point Fire of 1991. The upper portions of the Cliff and Cougar were affected by the Golden Fire; Goat Creek was not burned by the wildfire, but rather by an intentional "back-burn". Cave Creek serves as a reference for these sites. All of the above streams have a southern aspect. The upper portion of the Rush and Pioneer Creek catchments were minimally influenced by the Rush Point Fire and have northern aspects. Thus they provide a comparison with the south-facing streams listed above.

The 72,090 hectare Chicken landscape is located in the lower portion of the South Fork Salmon River Basin, from the confluence of the East Fork SFSR to the confluence of the Main Salmon. The South Fork Salmon River is a major tributary to the Main Salmon within the Columbia River System. The five sites examined included two watersheds: (1) Middle South Fork Salmon River Watershed and (2) Lower South Fork Salmon River Watershed. All of the S.F. Salmon tributaries we examined had a southeastern aspect. In the South Fork Salmon River catchment, Fritser Creek was moderately burned during the Chicken Fire of 1994 but the nearby Tailholt and Circle End Creeks were not. Although Tailholt and Circle End were examined beginning in 1994, Fritser Creek was not studied until 1995. Big Flat Creek was extensively burned by the Chicken Fire in 1994 and subsequently logged for salvage in 1996. The reference site, Smith Creek, was considerably larger than any of the logged streams, but provided the only accessible reference stream in the immediate area at the time the study was initiated due to numerous road closures related to the logging activities. In 1996 the extremely small size of Big Flat Creek precluded standard channel surveys and only qualitative macroinvertebrate samples were collected. No samples were collected in 1997 because of road closures due to the 1997 spring runoff event.

METHODS

Physical, chemical, and biological parameters were measured in all streams. Measurements of the physical habitat of the channel and water constituents provide important information about current stream conditions and are especially useful in year-to-year comparisons. Biological monitoring gives an indication of past as well as current ecological conditions. In 2000, Big Creek and the tributaries were sampled during three main times; pre-fire, post-fire but pre-runoff, and post-fire and runoff. The dates that correspond with each sampling time and the streams that were sampled are as follows: *pre-fire,* July 20-23, (Cliff, Pioneer, Goat, Cougar, Rush, and Cave Creeks); *post-fire but pre-runoff,* September 1-3, (Cliff, Pioneer, Cougar, Rush, Big Creek) and 28-30, (Cave Creek only, periphyton samples taken at Cliff, Pioneer, Cougar, and Rush Creeks) (category includes both September dates); *post-fire and runoff,* October 27-29, (Cliff, Pioneer, Cougar, Rush, Big Creek, Cave Creeks). The South Fork Salmon River sites were sampled July 26-28.

Field methods used for the various portions of this study are summarized in Table 2. The methods were consistent with methods used in our previous studies of wildfire and wilderness streams. These are relatively routine in stream ecology and are described in detail in standard reference sources (Stednik 1991, Merritt and Cummins 1996, APHA 1992, Platts et al. 1983, Davis et al. 2001).

Chemical measurements included specific conductance, alkalinity, and hardness. Specific conductance (S/cm@25^{0}C) was measured in the field with a temperature-compensated Orion meter. Water samples were collected and later analyzed in the laboratory for alkalinity and hardness (mg $CaCO_3$/l) by bromcreosol green and EDTA standard titration methods, respectively (APHA 1992).

Five transects approximately 50 m apart were sampled to measure changes in channel

Table 2. Summary of variables, sampling methods, and analytical procedures used in the study.

Variable	Type*	Sampling Method	Analytical Method
A. Physical			
Substratum Size	R	Measure x-axis of 100 randomly selected substrata	Calculate mean substratum size
Substratum Embed-dedness	R	Visual estimation of 100 randomly selected substrata	Calculate mean substratum embeddedness
Stream Width	T	Measure bankfull width using a nylon meter tape	Calculate mean stream width
Stream Depth	R	Measure water depth at the 100 randomly chosen substrata	Calculate mean water depth
Discharge	T	Velocity/depth profile Velocity measured with an Ott meter	Q=A x v; where Q=discharge, A=cross-sectional area, and V=mean velocity
B. Chemical			
Conductivity	P	Field measurement	Temperature comp-ensated meter (YSI 30)
Alkalinity	P	Water sample	Bromocresol green methyl red titration
Hardness	P	Water sample	EDTA titration
C. Biological			
Invertebrates	R	Collect 5 samples using a Surber sampler	Remove invertebrates, identify, enumerate, and analyze
Benthic Organic Matter	R	Recover from Surber samples	Determine AFDM
Periphyton	R	Collect 5 samples from individual substrata	Methanol extraction and spectrophotometric analysis

* P=point measure; T=transect across stream; R=random throughout a defined reach.

morphology and riparian conditions over time. In previous sampling years, and in the July 2001 sampling period these transects were identified by reference to local landmarks and by pacing. In the past this approach was prevented by thick riparian vegetation obscuring the views up- and downstream at most transect locations. Permanent markers (steel rebar and rock cairns on each bank) were not established until September 2001. Hydraulic gradient equals rise in stream height divided by the length of the stream reach examined. Gradient was determined with an inclinometer by measuring water surface elevations over several substantial reach lengths to give a good estimate of the mean. We now realize that this procedure for determining hydraulic gradient needs to be better replicated (e.g., n=10) and better linked to the transect locations. In the future, two measurements will be taken from a point at each transect, one upstream and one downstream. Stream discharge (m^3/s) was calculated at one cross-sectional transect by separating the transect into increments and multiplying the velocity by the cross-sectional area of the flow of each increment and then summing the increments (Bovee and Milhous 1978). An Ott C-1 or a Marsh McBirney current meter was used to determine mean water velocity at 0.6 water depth. In July we were not able to measure discharge due to malfunctioning of both of our counter boxes. Discharge for July was extrapolated from our long term data set using baseflow depths and channel widths. For many streams 2000 baseflow depth was the lowest recorded 1988-2000, therefore some approximations were made. Mean substratum size, water depths, and % embeddedness were measured at 100 locations throughout the channel along a substantial (ca. 200 meter) reach of the stream.

Benthic algal samples were collected from five rocks, one near each transect, using an areal sampler. A plastic tube was placed over the area of the substratum to be sampled. A neoprene gasket sealed the tube to the substrate and prevented the leakage of dislodged material. A known area (3.14 cm^2) was brushed using a hard bristled toothbrush and a syringe was used to remove the slurry and deposit it on a 0.45 μm pre-ashed glass fiber filter. Samples were immediately filtered and frozen with liquid nitrogen (and kept in the dark) to prevent degradation. In the laboratory, algal abundance was calculated by quantifying ash-free dry mass and chlorophyll *a* using standard methods (APHA 1992). September (1-3) AFDM samples were lost, so values were extrapolated from the chlorophyll values and the September (28-30) biomass:chlorophyll *a* ratios.

Methods for sampling benthic macroinvertebrates are described in Davis et al. (2001). Briefly, five quantitative Surber samples (929 cm^2 with a 250 μm mesh capture net) were collected from riffle/run habitats and preserved in 10% formalin. In the laboratory each macroinvertebrate sample was hand-sorted and identified to the lowest feasible taxonomic level using standard identification keys (Merritt and Cummins 1996, and others). After identification, the macroinvertebrates are dried at 50^0C, and weighed with a Cahn electrobalance to determine biomass. Benthic macroinvertebrate communities will be examined in terms of density, biomass, taxa richness, and Simpson's Index once sample processing is complete. Other community metrics also will be calculated when applicable. The sorting process separates the macroinvertebrates from the organic matter that occurs in the sample. The leftover organic matter is then dried and ashed to determine standing stock of benthic organic matter (BOM) in the stream.

RESULTS AND DISCUSSION

Big Creek and Big Creek Tributaries

Conductivity values for the Big Creek tributaries in July ranged from 115 in Pioneer Creek to 214 μS/cm @25^0C in Goat Creek (Table 3). In September, values for Big Creek and its tributaries (without Goat Creek) ranged from 109 at Cave Creek to 149 μS/cm @25^0C at Pioneer Creek. Conductivity values in October ranged from 116 in Big Creek to 171 μS/cm @25^0C in Cougar Creek. From the pre-fire to post-fire sampling dates Pioneer Creek increased substantially from 115 to 149 μS/cm @25^0C (Table 3). Conductivity in the remaining sites decreased (Cougar and Rush Creeks) or increased only slightly (Cliff Creek). Post-fire to post-fire-after-runoff comparisons showed an increase for only one stream, Cougar Creek, from 140 to 171 μS/cm @25^0C.

Alkalinity values for the Big Creek tributaries in July ranged from 37 to 78 mg $CaCO_3$/L at Cave and Goat Creeks, respectively (Table 3). September alkalinity values ranged from 47 at Rush Creek to 78 mg $CaCO_3$/L at Cougar Creek, and October values ranged from 42

Table 3. Physical and chemical characteristics of Big Creek and its tributaries in 2000.

Stream name	Conductivity (uS/cm @25^0 C)			Hardness (mg $CaCO_3$/L)			Alkalinity (mg CaCO3/L)		
	July	Sept	Oct	July	Sept	Oct	July	Sept	Oct
Rush Creek	131	125	134	40	40	113	46	47	55
Pioneer Creek	115	149	149	61	57	103	57	60	51
Cave Creek	NS	109	NS	34	46	115	37	56	54
Cliff Creek	128	133	119	44	51	109	50	57	52
Goat Creek	214	NS	NS	75	NS	NS	78	NS	NS
Cougar Creek	144	140	171	75	69	123	74	78	72
Big Creek	NS	120	116	NS	46	103	NS	48	42

	Slope (%)						Discharge (m^3/s)		
	July		Sept		Oct		July	Sept	Oct
	Mean	CV	Mean	CV	Mean	CV			
Rush Creek	2.7	1.5	1.8	1.0	1.5	0.5	1.1*	0.50	0.66
Pioneer Creek	5.3	0.6	10.0	2.0	4.0	1.0	0.1*	0.06	0.06
Cave Creek	3.8	0.8	4.3	1.5	3.7	0.6	0.16	0.06	0.12
Cliff Creek	10.0	2.6	11.7	4.5	3.7	0.3	0.09*	0.06	0.06
Goat Creek	26.0	8.2	NS	-	NS	-	0.02*	NS	NS
Cougar Creek	9.7	2.9	13.7	6.7	10.8	0.4	0.12*	0.04	0.07
Big Creek	NS	-	NS	-	1.0	0.0	NS	NS	NS

NS=no sample
*extrapolated from long term data

at Rush to 72 at Cougar Creek. Alkalinity values for most streams remained similar over the three sampling dates with the exception of Cave Creek, which had 37 mg $CaCO_3$/L in July and increased to 55 mg $CaCO_3$/L post-fire. Hardness values followed the same basic trends for ranges as alkalinity for within-date sampling for July and September. In July the hardness value was lowest in Cave Creek, (34) and highest in Cougar and Goat) (75) (Table 3). October hardness values (post-fire and runoff) were substantially higher than the previous two dates and ranged from 103 at Pioneer Creek to 123 mg $CaCO_3$/L at Cougar Creek.

Discharge for most streams was highest in July (pre-fire) decreased in September (post-fire) and increased in October (post-fire and post-runoff). Cliff and Pioneer Creeks, however, remained the same between September and October. Measured discharge in September was lowest in Cougar Creek 0.04 m^3/s, similar among the remaining 2nd and 3rd order tributary streams (0.06 m^3/s) and highest in 6th order Rush Creek, 0.5 m^3/s (Table 3). In October, values ranged from 0.06 at Cliff and Pioneer to 0.66 m^3/s at Rush Creek.

Active channel width was highest for most streams in July, except for Cliff Creek which was notably widest post-fire and runoff. The trend for the remaining streams was a decrease in active channel width after the fire, and then an increase in the post-runoff sampling period (Table 4). Mean baseflow depths remained consistent over the July, September, and October sampling dates for all streams except for Cave Creek (Table 4). Mean values in Cliff and Pioneer Creeks were 16, 16, 16 and 11, 13, 14 cm respectively (all values had a SD $<\pm 10$). In contrast, Cave Creek mean baseflow depths increased over the sampling dates from 11±8 and 12±7 cm in July and September to 29± 33 cm in October.

Mean substrate size increased slightly over the sampling dates (July to October) in Rush Creek, from 16 to 21 cm, but the rest of the streams showed a decreasing trend in mean substrate size (Table 4). Cave and Cliff Creeks decreased between July and September (17 and 23 cm to 10 and 17 cm, respectively) and then increased slightly in October during the post-fire post-runoff sampling period (to 12 and 18 cm) (Table 4), but the overall difference between July and October was that of a decreasing nature. Median substrate size followed mean substrate size trends, however Rush Creek joined Cliff and Cave Creek, decreasing slightly between the July and September sampling dates. Median substrate size increased in Rush Creek between July and

Table 4. Channel and substrate characteristics for Big Creek and its tributaries, 2000. NS = no sample

Stream Name	Mean Bankfull Width (m) n=5						Active Channel Width (m) n=5					
	July		September		October		July		September		October	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Rush Creek	13.7	1.6	17.9	4.9	15.2	2.1	9.2	1.2	8.0	1.0	8.0	1.0
Pioneer Creek	3.5	0.6	2.8	0.7	2.6	0.8	2.4	0.7	2.0	0.4	2.1	0.4
Cave Creek	8.1	2.6	4.9	0.9	8.3	3.2	4.1	0.7	3.4	1.0	3.6	1.0
Cliff Creek	3.1	0.7	5.3	2.1	4.7	2.0	2.6	0.8	2.3	2.0	3.2	1.1
Goat Creek	6.2	1.9	NS	-	NS	-	1.2	0.4	NS	-	NS	-
Cougar Creek	4.8	2.0	4.3	2.2	3.6	1.6	2.9	1.2	2.5	1.4	2.6	1.4
Big Creek	NS	-	NS	-	NS	-	NS	-	NS	-	NS	-

	Mean Baseflow Depth (cm) n=100						Median Substrate Size (cm) n=100					
	July		September		October		July		September		October	
	mean	CV	mean	CV	mean	CV	Med.	CV	Med.	CV	Med.	CV
Rush Creek	16.5	0.6	18.3	0.6	15.0	0.6	14.0	0.6	13.0	1.0	17.0	0.7
Pioneer Creek	10.8	0.6	12.9	0.6	13.9	0.6	9.0	1.5	8.8	1.0	7.0	1.1
Cave Creek	11.4	0.7	11.7	0.6	29.2	1.1	12.0	0.9	6.5	1.3	9.0	1.0
Cliff Creek	15.7	0.6	15.6	0.6	16.3	0.6	18.0	0.9	9.0	1.4	11.5	1.1
Goat Creek	6.4	0.8	NS	-	NS	-	6.5	1.3	NS	-	NS	-
Cougar Creek	13.3	0.8	13.2	0.8	13.9	0.7	15.0	1.1	12.0	1.3	11.0	1.1
Big Creek	NS	-	41.2	0.3	37.4	0.4	NS	-	25.0	0.5	31.0	0.5

	Mean Substrate Size (cm) n=100						Mean Embeddedness (%) n=100					
	July		September		October		July		September		October	
	mean	CV	mean	CV	mean	CV	mean	CV	mean	CV	mean	CV
Rush Creek	15.6	0.6	16.3	1.0	21.3	0.7	29.3	0.8	14.8	1.5	15.8	1.5
Pioneer Creek	13.7	1.5	11.1	1.0	9.9	1.1	19.0	1.3	18.1	1.4	19.3	1.5
Cave Creek	16.8	0.9	10.4	1.3	11.8	1.0	21.5	1.2	34.3	1.1	28.5	1.2
Cliff Creek	22.9	0.9	16.8	1.4	17.7	1.1	21.8	1.1	25.3	1.2	29.2	1.1
Goat Creek	15.0	1.3	NS	-	NS	-	23.0	1.3	NS	-	NS	-
Cougar Creek	23.3	1.2	23.2	1.3	18.6	1.1	21.0	1.3	18.0	1.5	14.8	1.5
Big Creek	NS		27.9	0.5	31.0	0.5	NS	-	17.3	1.2	25.5	1.1

October, while decreasing at all other sampling locations (Table 4). Mean substrate embeddedness displayed an increasing trend over the sampling dates in Cliff, Cave, and Big Creeks, but decreased in Rush and Cougar and remained the same in Pioneer (Table 4). Mean embeddedness ranged from 14 to 34% among the streams during the study period but most values fell between 17 and 27%. Lowest values of embeddedness were found in Rush and Cougar Creeks.

Mean periphyton chlorophyll *a* values ranged from 3 at Cougar Creek to 42 mg/m^2 at Cave Creek in July (Figure 1) and from 7 in Cougar Creek to 61 mg/m^2 at Big Creek in early September. In late September-early October, values ranged from 18 to 107 mg/m^2. Periphyton chlorophyll a values for most streams increased after the fire and decreased in the scouring post-fire post-runoff sampling period. Values did not increase immediately after the fire however, as the data for September indicate. However, by late September –early October values were substantially higher for almost all streams. Cave Creek mean periphyton chlorophyll *a* values did not increase between pre- and post- fire dates (although there is a large standard deviation). Periphyton AFDM values followed the chlorophyll *a* trends (Figure 1). The September 1-3 AFDM data were lost, but values were determined using B:C ratios from the September 27-29 data. Estimated AFDM for September 1-3 decreased from the July value in Rush and Pioneer Creeks but increased in the rest of the streams. Rush and Pioneer have northern aspects, which may account for these differences.

Benthic organic matter (BOM) was sampled on three separate occasions in 2000; during the months of July, September, and October. October samples were lost due to technician error; the samples were ashed without determining a baseline dry weight. July mean BOM ranged from 13 g/m^2 in Cougar Creek to 246 g/m^2 in Goat Creek (Figure 2). Between July and September 2000 (pre- and post-fire sampling dates), mean BOM values decreased slightly in Rush and Pioneer Creeks (from 46 and 72 to 30 and 61 g/m^2), while increasing substantially in Cliff and Cougar Creeks (from 18 to 99 and 13 to 126 g/m^2, respectively). All streams except for Cave Creek experienced the highest mean BOM value of the entire study period in 2000 (Figure 2).

Mean macroinvertebrate taxa richness ranged from 38 in Goat to 57 in Rush Creeks,

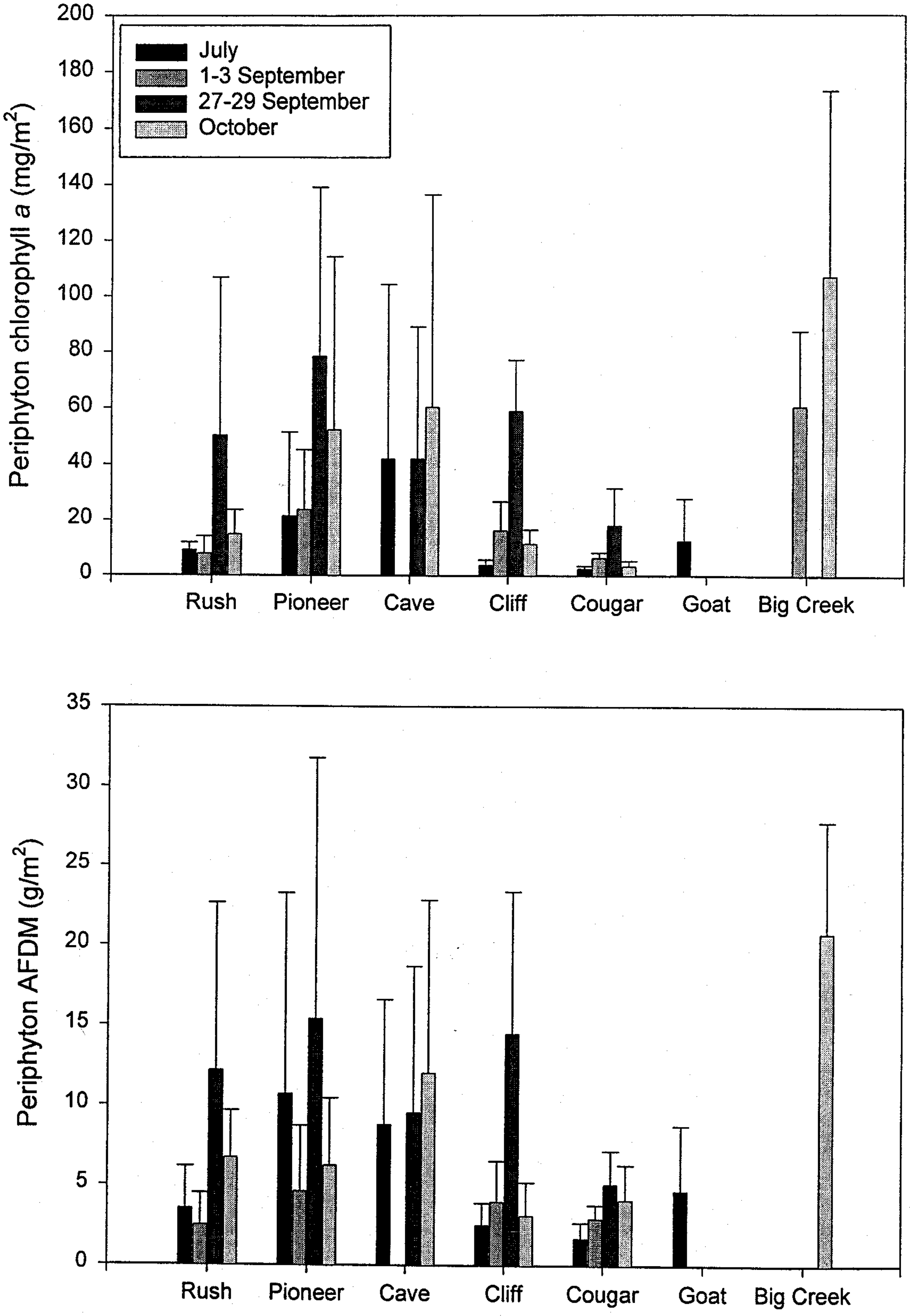

Figure 1. Periphyton chlorophyll a and AFDM for Big Creek and six of its tributaries for four sampling dates during 2000.

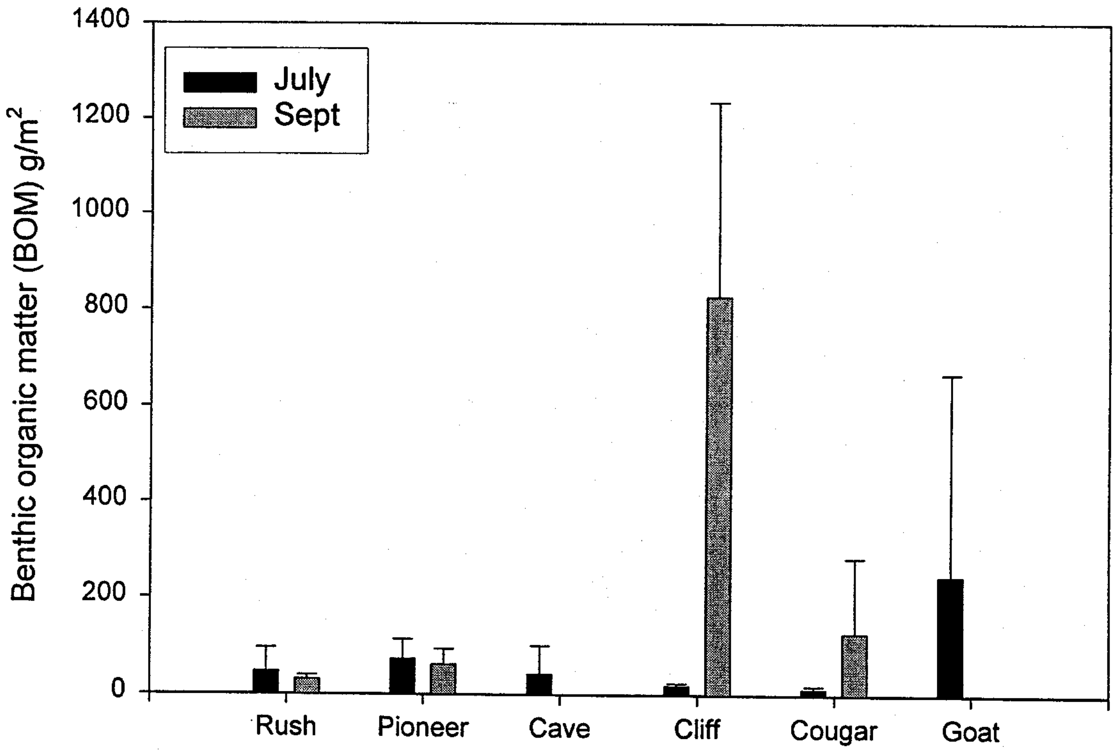

Figure 2. Benthic organic matter for the Big Creek tributaries for July and September, 2000. n=5

respectively (Figure 3). Mean richness increased in all streams from 1999 to 2000. Richness was exceptionally high in Rush Creek when compared to the long-term range. Similarly, although Goat Creek had the lowest mean taxa richness among the tributaries sampled in 2000, 38 (SD 3) was the highest value recorded in the ten-year sampling period (Figure 3). For the remaining streams, mean macroinvertebrate taxa richness fell within the long-term ranges.

Mean macroinvertebrate density ranged from 800-37,600 macroinvertebrates/m^2 in the Big Creek tributaries in 2000 (Figure 4). Density was lowest in Goat Creek, as was the case in most years, and highest in Rush Creek. Mean densities increased from the 1999 to 2000 sampling periods in Rush, Cave and Cougar Creeks and decreased in the other three streams. Mean macroinvertebrate densities in Rush and Cave Creeks, 37,600 (SD 16,050) and 27,000 (SD 7,000) macroinvertebrates/m^2 during 2000 were the highest mean macroinvertebrate densities recorded in the thirteen- and ten-year respective sampling periods. However, the 1600 (SD 400) macroinvertebrates/m^2 recorded in Cliff Creek was the lowest mean density recorded in its' thirteen year sampling history (Figure 4).

Mean macroinvertebrate biomass ranged from 700-2950 mg/m^2 in the Big Creek tributaries in 2000 (Figure 5). Mean biomass was lowest in Cougar Creek and highest in Rush Creek. From 1999 to 2000 biomass estimates increased or remained the same between years in all streams except for Goat Creek. The most abundant species of Goat Creek in terms of 2000 biomass was substantially Oligochaeta, 37% (the next abundant taxa were *Rhyacophila brunnea* and *Tipula* both with 7% abundance). Cliff Creek biomass was more evenly divided between several species: 17% Oligochaeta, 15% *Parapsyche elsis*, 11% *Cinygmula* sp., 9% *Drunella doddsi*, 6% Tricladia, etc.

Simpson's Index values ranged from 0.14 in Goat and Cave Creeks to 0.21 in Cougar Creek (Figure 6). Mean Simpson's Index values tended to decrease between 1999 and 2000 in Pioneer, Goat, and Cougar Creeks, although not as obviously in Cougar Creek. All values found in 2000 were within the long-term averages (Figure 6).

Oligochaeta was the dominant taxon in three streams: Cougar, Cliff, and Goat Creeks (Table 5). The dominant taxa in Cave Creek were *Baetis* (18%), Oligochaeta (16%) and Chironomidae (13%). Chironomidae also was the dominant taxon in Rush Creek with 32%. The

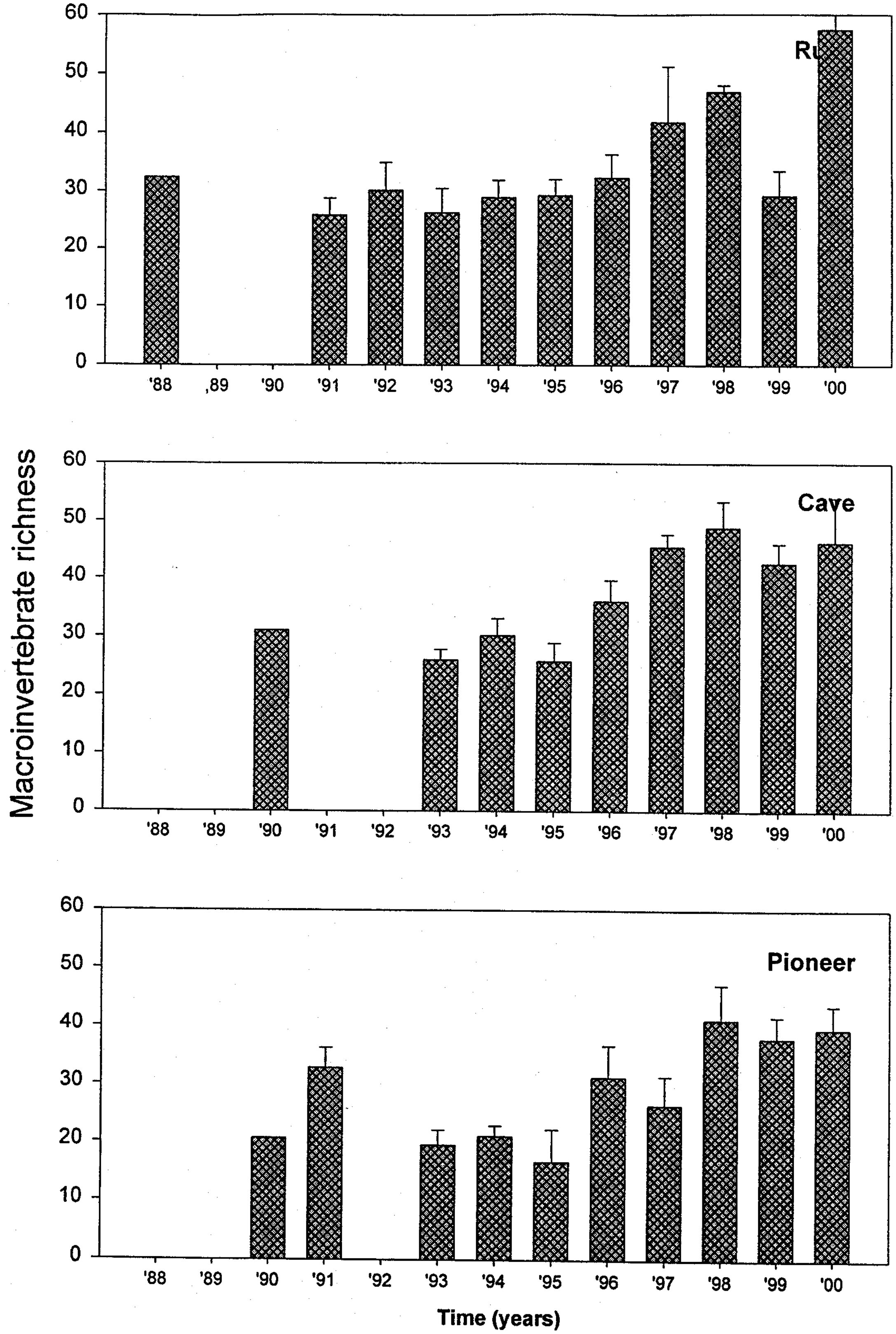

Figure 3. Mean macroinvertebrate richness for each stream. Error bars equal +1SD from the mean, n=5.

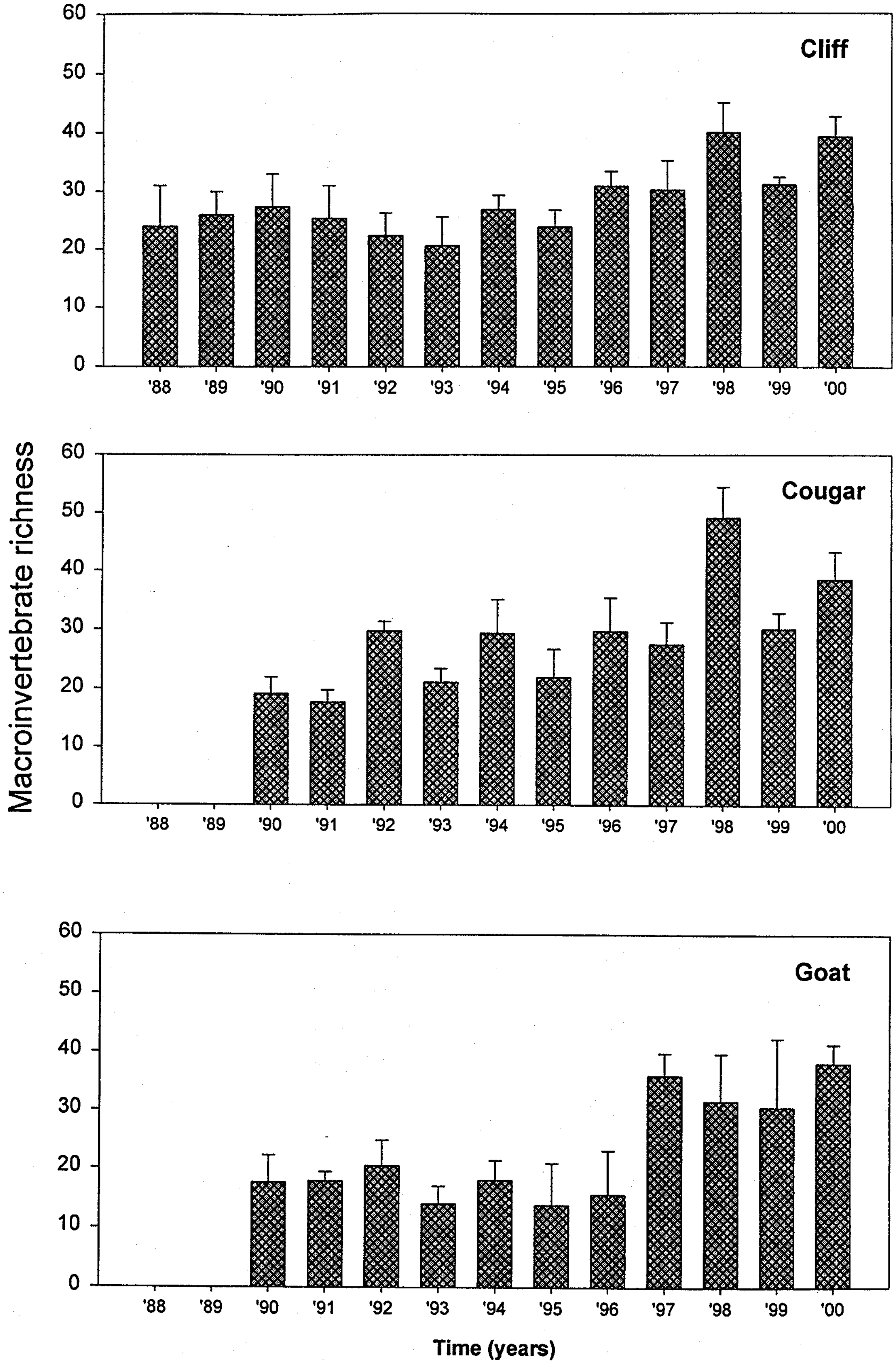

Figure 3 continued.

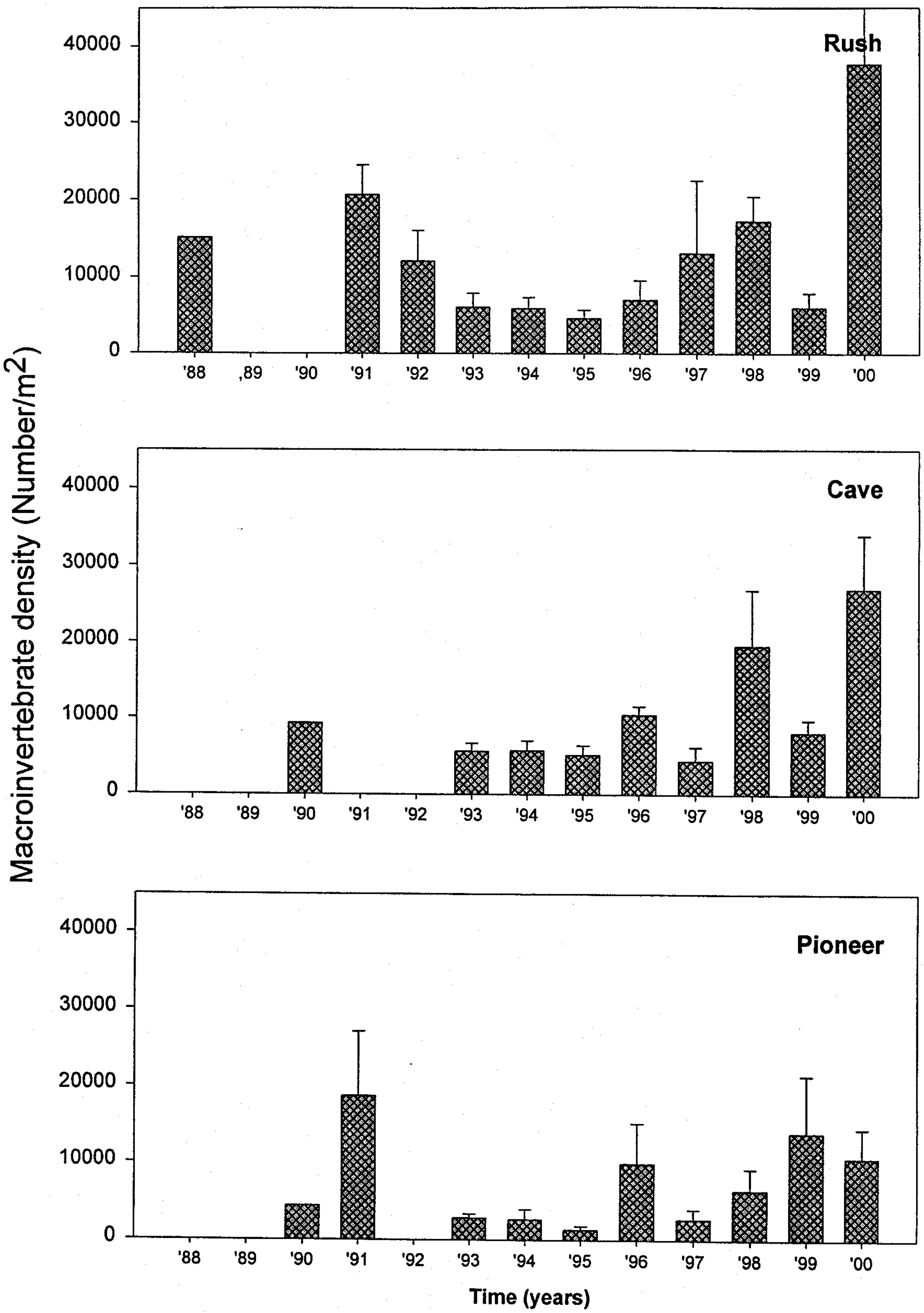

Figure 4. Mean macroinvertebrate density for each stream. Error bars equal +1SD from the mean, n=5.

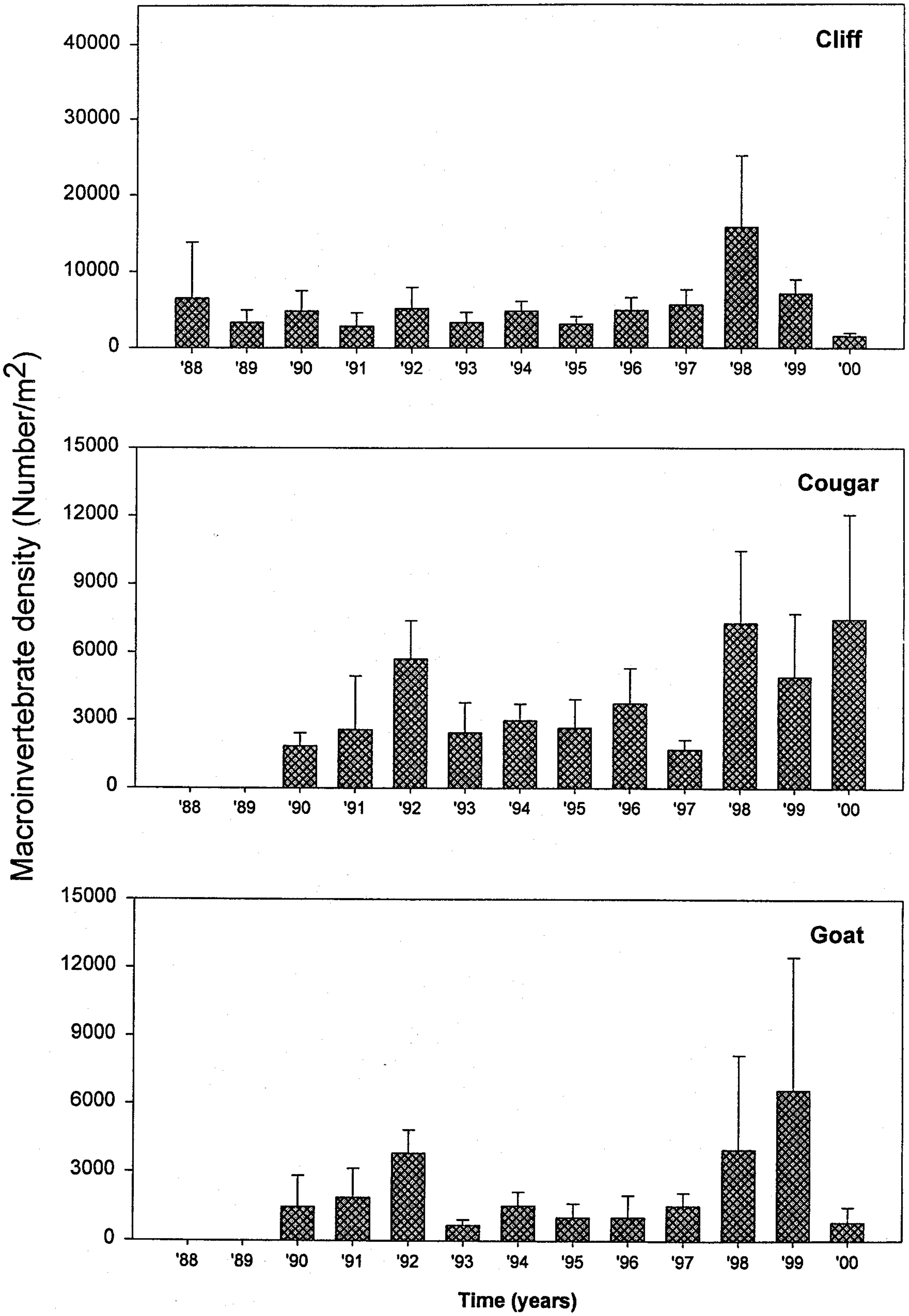

Figure 4 continued.

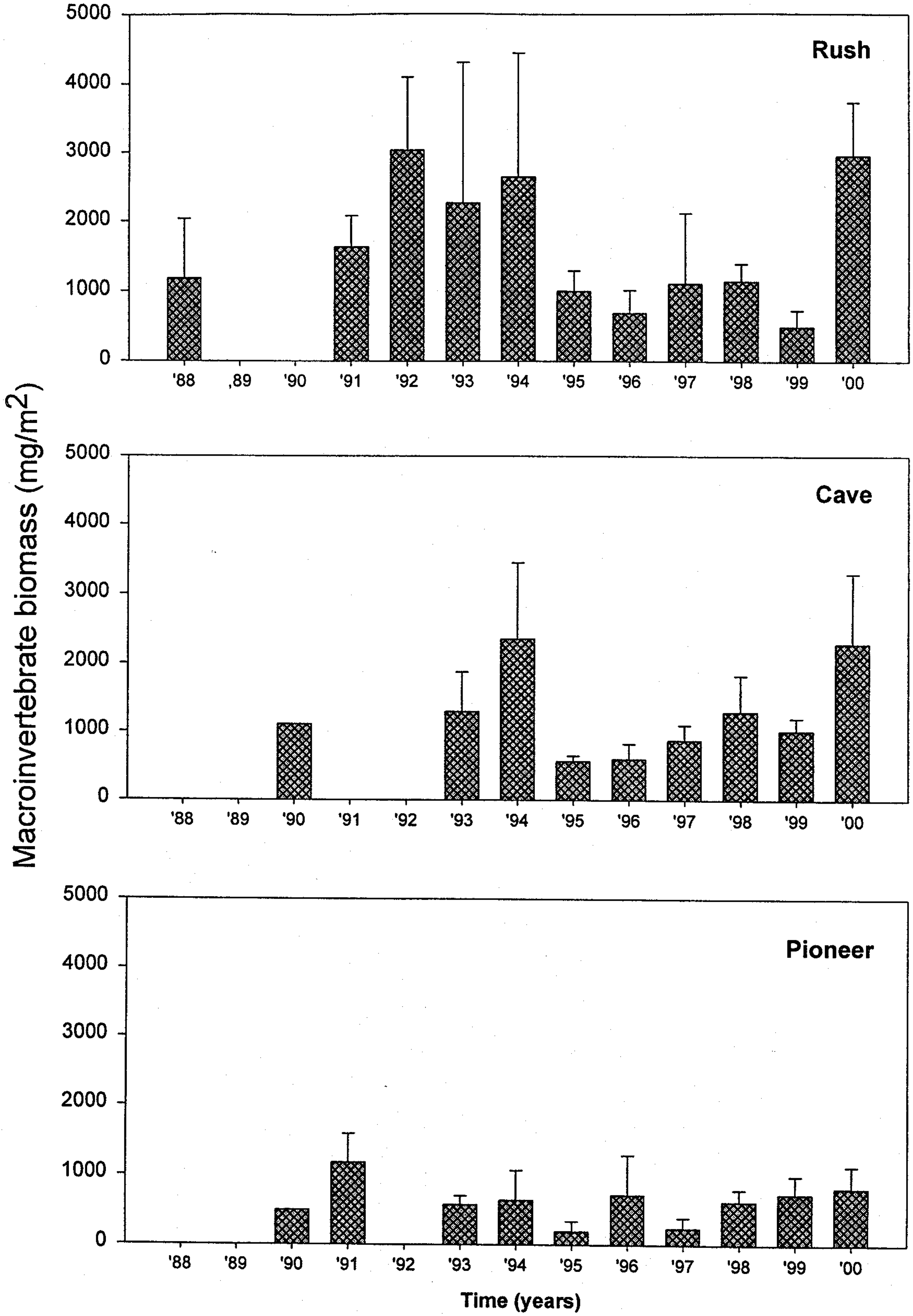

Figure 5. Mean macroinvertebrate biomass for each stream. Error bars equal +1SD from the mean, n=5.

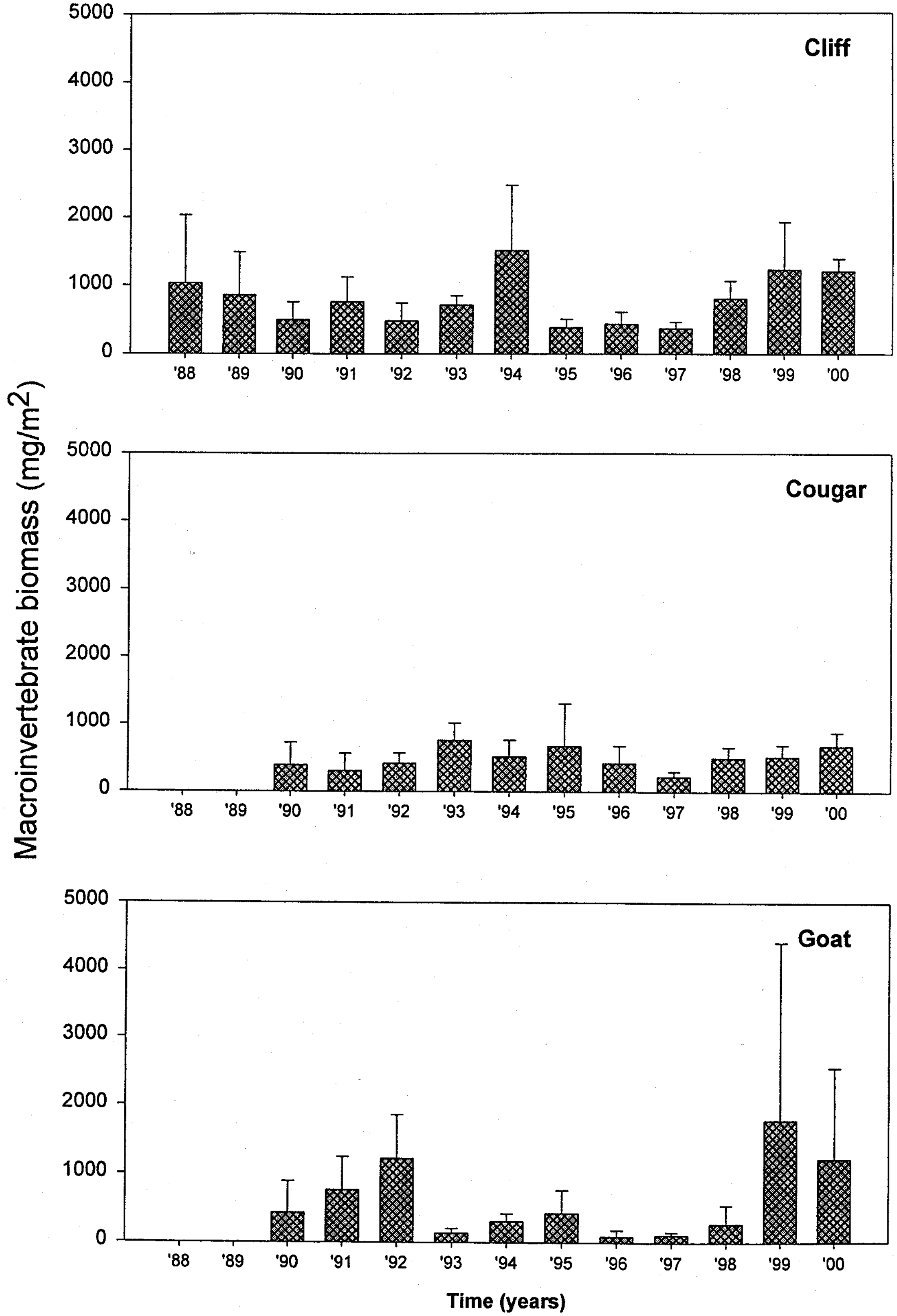

Figure 5 continued.

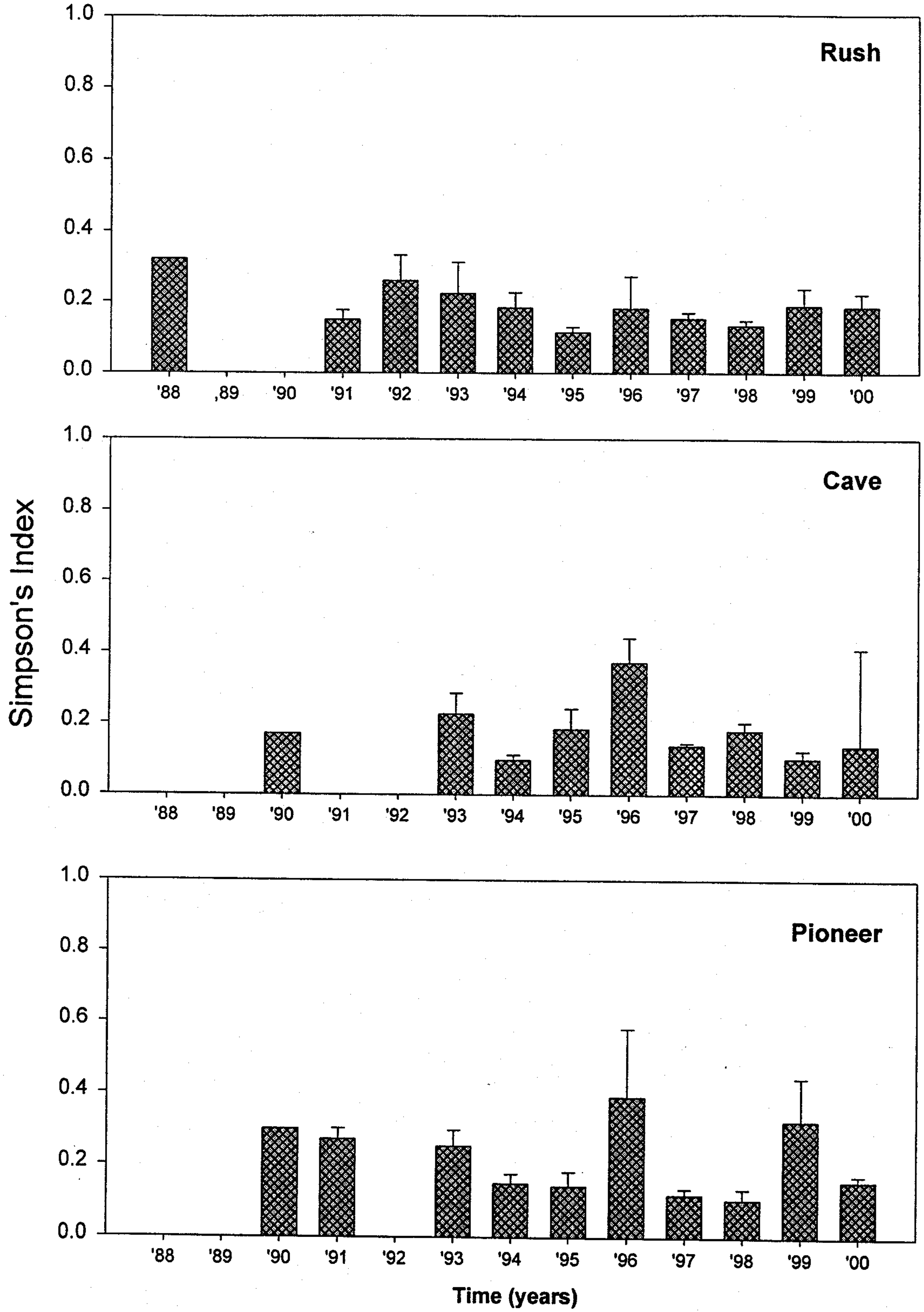

Figure 6. Mean macroinvertebrate Simpson's Index for each stream. Error bars equal +1SD from the mean, n=5.

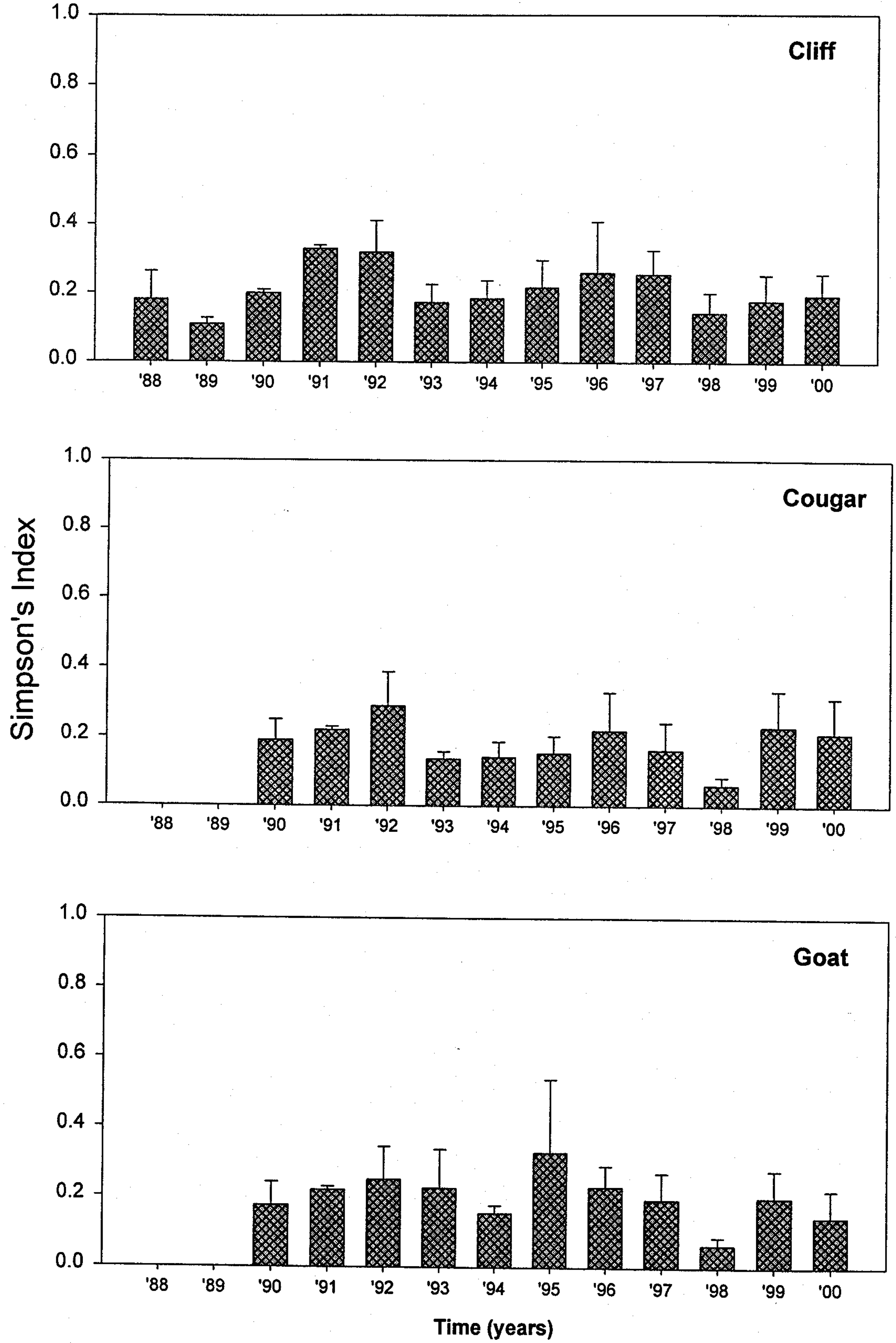

Figure 6 continued.

Table 5. Fifteen most relative abundant macroinvertebrate taxa in the Big Creek tributaries in July, 2000. n=5

Cave	mean	SD
Baetis spp.	18.09	9.92
Oligochaeta	15.85	13.98
Chironomidae	12.51	5.79
Heterlimnius spp.	9.00	5.66
Elmidae spp.	5.80	4.39
Hydracarina	5.58	2.23
Ostracoda	5.34	3.98
Heptageniidae spp.	4.61	3.04
Zapada spp.	4.29	8.00
Uenoidae spp.	2.37	2.17
Timpanoga hecuba	2.10	2.80
Antocha spp.	1.45	2.23
Hydropsychidae spp.	1.26	1.69
Sweltsa spp.	1.21	0.96
Nematoda	0.80	0.89

Rush	mean	SD
Chironomidae	32.10	8.67
Baetis spp.	17.38	10.63
Glossosoma spp.	9.85	8.26
Oligochaeta	8.38	6.18
Heptageniidae spp.	6.13	2.87
Hydracarina	5.57	0.62
Hydropsychidae spp.	2.22	1.75
Zapada spp.	1.65	1.49
Limnephilidae spp.	1.31	1.19
Sweltsa spp.	1.18	0.72
Ostracoda	1.13	0.39
Nematoda	0.79	0.39
Chloroperlidae spp.	0.77	0.29
Serratella tibialis	0.76	0.33
Lepidostoma spp.	0.74	0.62

Pioneer	mean	SD
Ostracoda	26.66	7.18
Oligochaeta	15.83	9.50
Heterlimnius spp.	11.67	8.39
Elmidae spp.	9.20	8.13
Baetis spp.	5.70	4.27
Cinygmula spp.	4.87	2.02
Chironomidae	3.85	2.59
Sweltsa spp.	2.37	1.73
Chloroperlidae spp.	2.01	2.48
Capniidae spp.	1.54	0.69
Uenoidae spp.	1.52	1.10
Rhyacophila spp.	1.43	0.59
Copepoda spp.	1.34	2.17
Zapada spp.	1.18	1.34
Epeorus longimanus	1.02	0.97

Cliff	mean	SD
Oligochaeta	37.60	7.67
Ostracoda	14.96	7.13
Chironomidae	5.81	1.65
Drunella doddsi	5.09	1.72
Baetis spp.	3.85	2.88
Zapada spp.	3.10	2.22
Rhithrogena robusta	3.00	2.01
Cinygmula spp.	2.66	1.18
Uenoidae spp.	2.65	1.60
Heterlimnius spp.	2.28	1.00
Dolophilodes spp.	2.17	2.54
Glossosoma spp.	1.84	0.96
Nemouridae spp.	1.84	1.44
Epeorus spp.	1.80	1.07
Elmidae spp.	1.31	0.60

Goat	mean	SD
Oligochaeta	19.39	13.91
Glossosoma spp.	12.83	18.59
Elmidae spp.	9.16	5.12
Chironomidae	8.38	6.16
Baetis spp.	7.23	4.20
Cleptelmis spp.	6.29	4.97
Ostracoda	5.08	3.10
Zapada spp.	4.50	2.50
Ephemerellidae spp.	3.17	1.82
Heterlimnius spp.	3.16	2.57
Hydracarina	2.45	1.47
Paraleptophlebia memorialis	1.21	2.22
Tricladida spp.	1.09	0.67
Collembola spp.	1.02	1.23
Pericoma spp.	0.99	1.26

Cougar	mean	SD
Oligochaeta	31.39	19.83
Heterlimnius spp.	11.59	7.10
Glossosoma spp.	10.93	17.10
Baetis spp.	7.62	10.09
Elmidae spp.	5.79	3.58
Chironomidae	4.51	0.37
Ostracoda	4.01	2.10
Zapada spp.	3.06	2.34
Uenoidae spp.	3.01	4.54
Cinygmula spp.	2.07	0.82
Epeorus spp.	1.59	2.26
Tricladida spp.	1.29	0.43
Hydropsychidae spp.	1.17	0.81
Hydracarina	0.99	1.01
Rhyacophila brunnea	0.82	1.37

macroinvertebrate community in Pioneer Creek was dominated by Ostracoda (27%). Other abundant macroinvertebrates included Elmidae, Nemouridae, and Heptageniidae (Table 5).

South Fork Salmon River Tributaries

Relatively minor changes were observed in the measured water chemistry variables in all South Fork Salmon streams in 2000 (Table 6). In 2000, all streams except for Fritser Creek decreased in alkalinity. Streams in the middle part of the watershed decreased in hardness values while those in the lower part (Smith and Big Flat) increased. For those streams in the middle part of the watershed (Circle End, Tailholt and Fritser), hardness values recorded in 2000 were the lowest values recorded over the six-year sampling period. Although they are all located in the middle part of the watershed, Circle End and Tailholt Creeks contained considerably more dissolved solids than does Fritser Creek. Also, specific conductance and alkalinity were 2-3 fold greater in Circle End and Tailholt Creeks than in Fritser Creek (Table 6). However, this difference was more pronounced in the late 1990s, specific conductance and alkalinity values in Circle End and Tailholt Creeks were 5-6 and 3-4 fold greater than those measured in Fritser Creek. Fritser Creek has steadily increased in alkalinity from 1995 to 2000, from 10 to 26 mg $CaCO_3$/L. Specific conductance in 2000, was considerably higher than that measured in previous years, 46 vs.~25 µS/cm@25^{0}C. Circle End and Tailholt Creeks had specific conductance (117 and 96 µS/cm@25^{0}C) and alkalinity (70 and 50 mg $CaCO_3$/L) values in 2000 that fell within the long-term ranges measured at each respective site. Among the sites in the salvage logging area, conductance and alkalinity varied considerably between Smith Creek and Big Flat Creek (Table 6). Big Flat was most similar to Tailholt in water chemistry measures although they were located in separate watersheds, the middle vs. lower South Fork Salmon River watersheds.

Discharge was not measured in 2000 due to malfunction of the recording boxes but all streams except for Fritser Creek increased in bankfull width from 1999 to 2000 (Table 7). Smith Creek has almost doubled in mean width between 1996 and 2000. This increase is mainly due to the widening of the three lowest transects, below the input of a tributary that scoured the channel in 1997. Some of the variation in bankfull width measurements at the remaining sites is likely due to variation of field measurement location between years. Permanent transects are not

Table 6. Discharge and chemical measures for the study streams in the S. Fork Salmon catchment. NS = no sample, NA = not available

Stream	Year	Discharge (m3/s)	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)	Conductance (uS/cm @ 20C)
Circle End	1994	0.01	NS	NS	186
	1995	0.01	52	68	149
	1996	0.01	40	65	129
	1998	0.01	58	69	NS
	1999	0.13	84	85	112
	2000		70	61	117
Tailholt	1994	0.02	NS	NS	143
	1995	0.06	30	56	108
	1996	0.07	28	53	76
	1998	0.05	39	48	NS
	1999	0.09	67	49	85
	2000		50	40	96
Fritser	1995	0.27	10	28	27
	1996	0.42	10	20	NA
	1998	0.14	21	28	NS
	1999	0.37	24	21	23
	2000		26	18	46
Smith	1996	0.12	16	44	54
	1998	0.12	25	40	NS
	1999	0.79	38	23	40
	2000		30	26	39
Big Flat	1996	NS	24	57	102
	1998	0.05	41	59	NS
	1999	0.42	60	39	90
	2000		48	47	89

Table 7. Substrate particle size and channel morphology measures for study streams in the South Fork Salmon catchment. SD = standard deviation, CV = coefficient of variation. R=reference, B=burned in 1994, S=logged in 1996. NS = no sample.

			Substrate Size (cm)			Substrate Embeddedness (%)			Bankfull Width (m)		Baseflow Depth (cm)	
Stream	Year	Median	mean (n=100)	SD	CV	mean (n=100)	SD	CV	mean (n=5)	SD	mean (n=100)	SD
Circle End (R)	1994	16.0	14.0	39.0	2.9	38.0	45.0	1.2	0.7	0.2	4.0	3.0
	1995	30.0	30.0	27.0	0.9	64.0	29.0	0.5	1.2	0.4	5.0	5.0
	1996	4.0	19.0	44.0	2.3	58.0	42.0	0.7	1.3	0.5	7.0	6.0
	1998	0.0	7.6	13.0	1.7	39.5	41.7	1.1	3.8	1.6	5.4	5.1
	1999	13.0	11.0	9.7	0.9	8.5	22.1	2.6	3.5	0.7	5.4	4.3
	2000	27.5	49.1	46.0	0.9	9.0	23.4	2.6	3.7	0.4	3.3	3.2
Tailholt (R)	1994	16.0	13.0	30.0	2.4	23.0	33.0	1.5	1.2	0.2	10.0	5.0
	1995	3.0	20.0	30.0	1.5	76.0	30.0	0.4	1.7	0.2	19.0	11.0
	1996	0.1	13.0	30.0	2.3	72.0	37.0	0.5	1.7	0.6	15.0	9.0
	1998	0.0	8.9	14.1	1.6	64.3	41.6	0.7	3.3	0.6	14.5	9.1
	1999	4.0	13.6	19.4	1.4	14.3	25.8	1.8	2.1	0.6	16.7	13.1
	2000	1.5	17.7	30.6	1.7	11.3	22.0	2.0	2.6	0.3	11.4	6.5
Fritser (B)	1995	40.0	42.0	36.0	0.8	55.0	33.0	0.6	2.8	0.4	26.0	19.0
	1996	11.5	23.0	38.0	1.7	58.0	39.0	0.7	2.4	0.9	18.0	12.0
	1998	14.0	21.5	29.6	1.4	55.5	36.2	0.7	5.6	2.0	17.9	13.4
	1999	6.5	19.1	30.1	1.6	18.8	21.0	1.1	5.2	0.8	28.5	16.8
	2000	13.5	30.2	36.4	1.2	15.5	24.6	1.6	4.2	1.1	16.3	12.4
Smith (R)	1996	10.0	13.0	11.0	0.9	51.0	39.0	0.8	3.2	0.3	17.0	9.0
	1998	11.5	19.3	26.4	1.4	45.1	28.2	0.6	5.4	2.2	15.2	11.5
	1999	14.0	18.7	20.2	1.1	17.0	26.0	1.5	5.2	0.8	24.3	13.8
	2000	7.8	16.4	25.2	1.5	24.5	32.0	1.3	6.1	0.8	12.5	9.3
Big Flat (S)	1996		NS			NS			NS		NS	
	1998	8.0	23.9	36.2	1.5	37.5	36.7	1.0	3.9	1.8	7.5	7.4
	1999	13.0	27.7	36.5	1.3	5.8	13.6	2.4	3.1	0.4	8.6	8.2
	2000	7.0	23.9	32.3	1.4	13.5	23.7	1.8	3.4	1.1	6.9	6.1

established on the South Fork Salmon sites. Fritser Creek decreased in bankfull width from 1999 to 2000 from 5.2 to 4.2 m. This measurement is likely due to variation in field measurement. All streams decreased in baseflow depth between 1999 and 2000. While some of this decrease is due to the increase in stream width, 2000 was a low flow year and discharges appeared to be reduced at all locations. Baseflow depths in Fritser Creek, located in the middle part of the watershed, decreased from 29 to 16 cm and from 24 to 13 cm in Smith Creek, located in the lower part of the watershed.

Mean substrate size increased from 1999 to 2000 at all sites in the middle SFSR watershed and decreased at sites in the lower SFSR watershed (Table 7). Circle End Creek increased from 11 to 49 cm and Fritser Creek from 19 to 30 cm, while mean substrate size decreased in both (burned and logged) Big Flat Creek (28 to 24 cm) and Smith Creek (19 to 16 cm) between 1999 and 2000. Median substrate size followed similar temporal trends as mean substrate size for Circle End and Fritser Creek, increasing between 1999 and 2000; and for Smith and Big Flat Creek, decreasing between years. In Tailholt Creek, however, mean substrate size increased between 1999 and 2000 (14 to 18 cm) while median substrate size decreased slightly (4 to 1.5 cm). Mean substrate embeddedness remained the same or decreased at sites in the middle part of the watershed and increased at sites in the lower part of the watershed between 1999 and 2000 (Table 7). Embeddedness decreased from 14 to 11% in Tailholt Creek and from 19 to 15% in Fritser Creek. Increases in substrate embeddedness were just as small in the lower part of the watershed, from 6 to 14% and 17 to 25% in Big Flat and Smith Creeks, respectively. Changes in substrate embeddedness between 1999 and 2000 were much less than the changes between 1998 and 1999 (Table 7). For the streams in the middle part of the watershed, the CVs were high in 2000, 1.6-2.6, considering that from 1995-1998 they were generally <1.0.

Mean periphyton chlorophyll *a* in the South Fork Salmon River tributaries ranged from 1.1 mg/m^2 at Fritser Creek to 166.0 mg/m^2 at Circle End Creek (Figure 7). Mean chlorophyll *a* in Big Flat Creek was 3 mg/m^2, compared to 11 mg/m^2 at Smith Creek. Values for both streams were within the ranges for the number of years sampled for each stream (three and four, respectively). Periphyton chlorophyll *a* in Fritser Creek in 2000 was similar to that recorded in 1999 (1.1 and 1.7 mg/m^2) and was not substantially different from Tailholt Creek (3.2±2.3

mg/m^2), one of its reference streams (Figure 7). Circle End Creek chlorophyll *a* values, 166±93 mg/m^2, and AFDM values are likely due to the overabundant presence of *Nostoc* on the substrate. Periphyton AFDM was highest in Circle End (50 g/m^2) and lowest in Fritser Creek (2.8 g/m^2) (Figure 7). As mentioned, the high value at Circle End Creek was likely due to the large amount of *Nostoc* and enmeshed organic matter on the substrate. Similar to chlorophyll, periphyton biomasses in Big Flat and Smith Creeks were not substantially different from one another. Fritser and Tailholt Creeks AFDM also were not substantially different (Figure 7).

Benthic organic matter (BOM) overall ranged from 29±27 g/m^2 in Big Flat Creek to 80±101 g/m^2 in Tailholt Creek (Figure 8). Mean BOM decreased slightly between 1999 and 2000 in reference Fritser Creek (44 to 36 g/m^2) while increasing in both Circle End and Tailholt Creeks, although BOM values are traditionally variable (23±16 to 64±62 g/m^2 and 39±24 to 80±101 g/m^2, respectively). The mean BOM value for Tailholt was the highest value recorded in the six sample dates since 1994. Big Flat Creek BOM values increased between 1999 and 2000 from 12±9 to 29±27 g/m^2 as did its reference stream reference stream, Smith Creek, 13±4 to 46±22 g/m^2 (Figure 8). The Big Flat Creek 2000 BOM value, although not substantially different from 1998, also was the highest mean value recorded in the three years sampled.

Macroinvertebrate taxa richness overall ranged from 43 in Tailholt to 65 taxa in Smith Creek (Figure 9). Year 2000 values were the highest values of taxa richness recorded, not surprisingly, due to the high densities experienced, as noted above. Fritser Creek richness from 1995-1999 was consistently 30 taxa, but increased to 45 taxa in 2000. Circle End and Tailholt Creeks had more annual variability in taxa richness than Fritser Creek over the study period, but their 2000 richness values were similar, 44±12 and 43±12 taxa. Smith Creek richness, in most years, has had the highest stream richness value. In 2000 Smith Creek had 65±4 taxa, while Big Flat Creek had 44±9 taxa. These values were increases from 1999 values of 31 and 21 taxa, respectively (Figure 9). Although 65 is a high value for richness, especially compared to nearby streams and previous years, it is plausible especially due to the low standard deviation. One transect (T5) of Smith Creek was sampled a little farther upstream than in previous years, but if this had been a significant factor, it would have been evident in the standard deviation of the community metrics, which it was not.

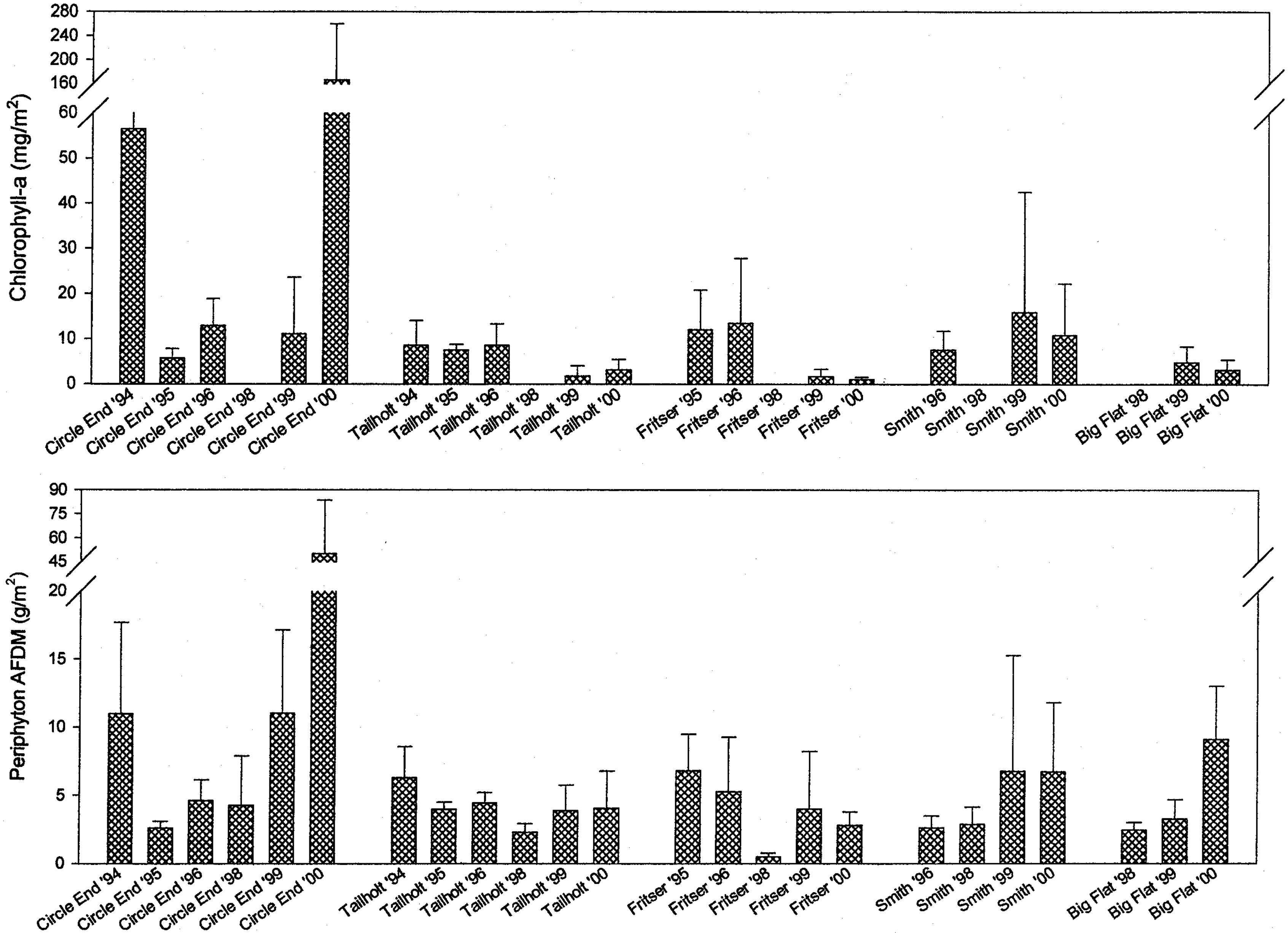

Figure 7. Mean periphyton chlorophyll *a* and ash-free dry mass (AFDM) in each stream, 1994-2000. Error bars equal +1SD, n=5. Big Flat Creek data was not collected in 1996 and lost due to technician error in 1998.

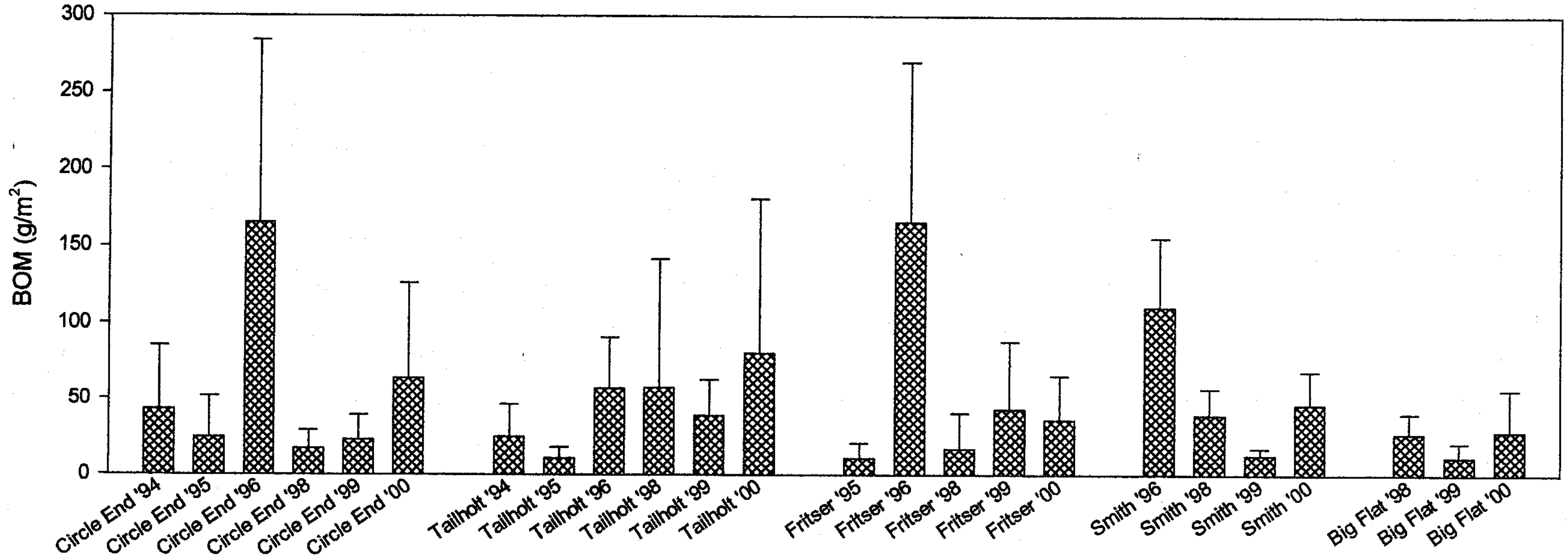

Figure 8. Mean benthic organic matter (BOM) dry mass in each stream, 1994-2000. Error bars equal +1SD from the mean, n=5. Big Flat Creek data was not collected in 1996.

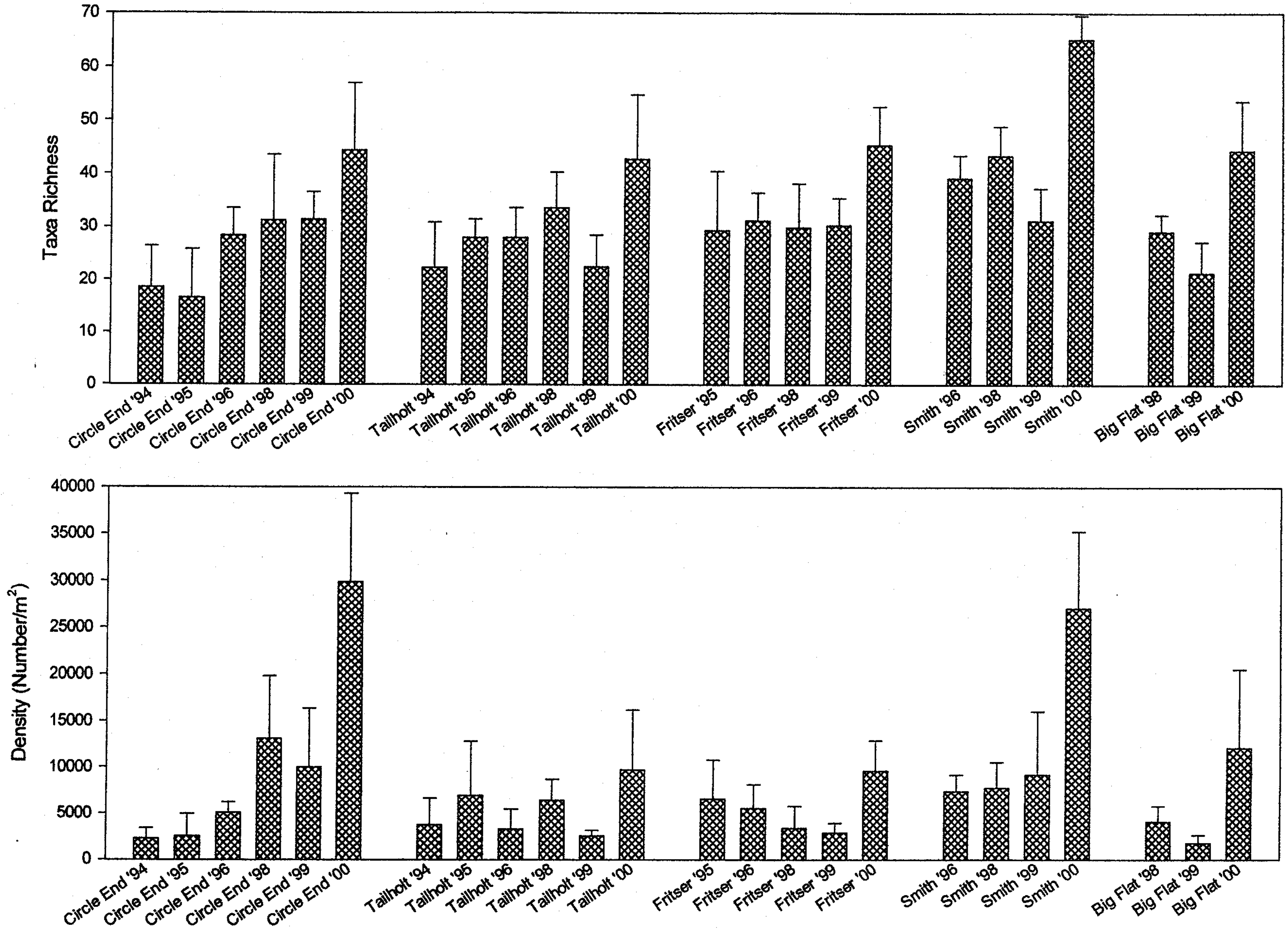

Figure 9. Mean macroinvertebrate taxa richness and density for each stream, 1994-2000. Error bars equal +1SD from the mean, n=5.

Macroinvertebrate density ranged from 9585±3200 in Fritser Creek to 29,900±9400 in Circle End Creek (Figure 9). Year 2000 density values for all South Fork Salmon streams were the highest recorded values for every stream for each of their respective sampling periods. Density increased substantially in most streams between 1999 and 2000. Fritser and Tailholt increased similar amounts from 2847 to 9585 macroinvertebrates/m^2 and 2554 to 9700 macroinvertebrates/m^2 while Circle End increased from 10,040 to 29,9224 macroinvertebrates/m^2. Big Flat increased from 1761 to 12,051 while it's reference stream reference Smith Creek increased from 9157 to 27,053 macroinvertebrates/m^2 (Figure 9).

Macroinvertebrate biomass in 2000 ranged from 6168±729 mg/m2 in Tailholt Creek to 2468±1283 mg/m2 in Smith Creek (Figure 10). Mean biomass increased in all streams between 1999 and 2000. In the upper part of the watershed, Fritser Creek increased from 891±597 to 1201±992 mg/m2 while Circle End increased from 1126±657 to 2190±1095 mg/m2. The 1999 datum for Tailholt was lost, therefore no comparison between years can be made for that stream. Year 2000 values for these three streams are the highest recorded mean values thus far. In the lower part of the watershed, Smith Creek increased from 1077±554 to 2468±1283 and Big Flat Creek increased from 447±150 to 1152±1224 (Figure 10). These 2000 values also were the highest values recorded over the sampling period.

Simpson's Index values ranged from 0.09 in Smith Creek to 0.32 in Circle End Creek (Figure 10). In Fritser Creek Simpson's Index values during 1995-1999 remained a consistent 0.15 and decreased to 0.12 in 2000. Tailholt Creek index values decreased from 0.34±.0.21 to 0.20±0.15 from 1999 to 2000 (Figure 10). Circle End Creek increased slightly over the same time period, from 0.29±.0.12 to 0.32±0.03. In the lower part of the watershed, both Big Flat and Smith Creeks decreased in value from 1999 to 2000, from 0.19 and 0.25 to 0.13 and 0.09 (Figure 10).

Unlike the Big Creek tributaries in which Oligochaeta was the dominant taxon, *Baetis* was the most abundant taxon in all of the South Fork Salmon River tributaries except for Circle End Creek, in which it still had a high abundance, 32% (Table 8). Chironomidae also ranked in the top four taxa of each stream, ranging from 8 to 49% of the macroinvertebrate community. Other abundant taxa included *Caudatella, Zapada*, Ephemerellidae, Elmidae, and Capniidae

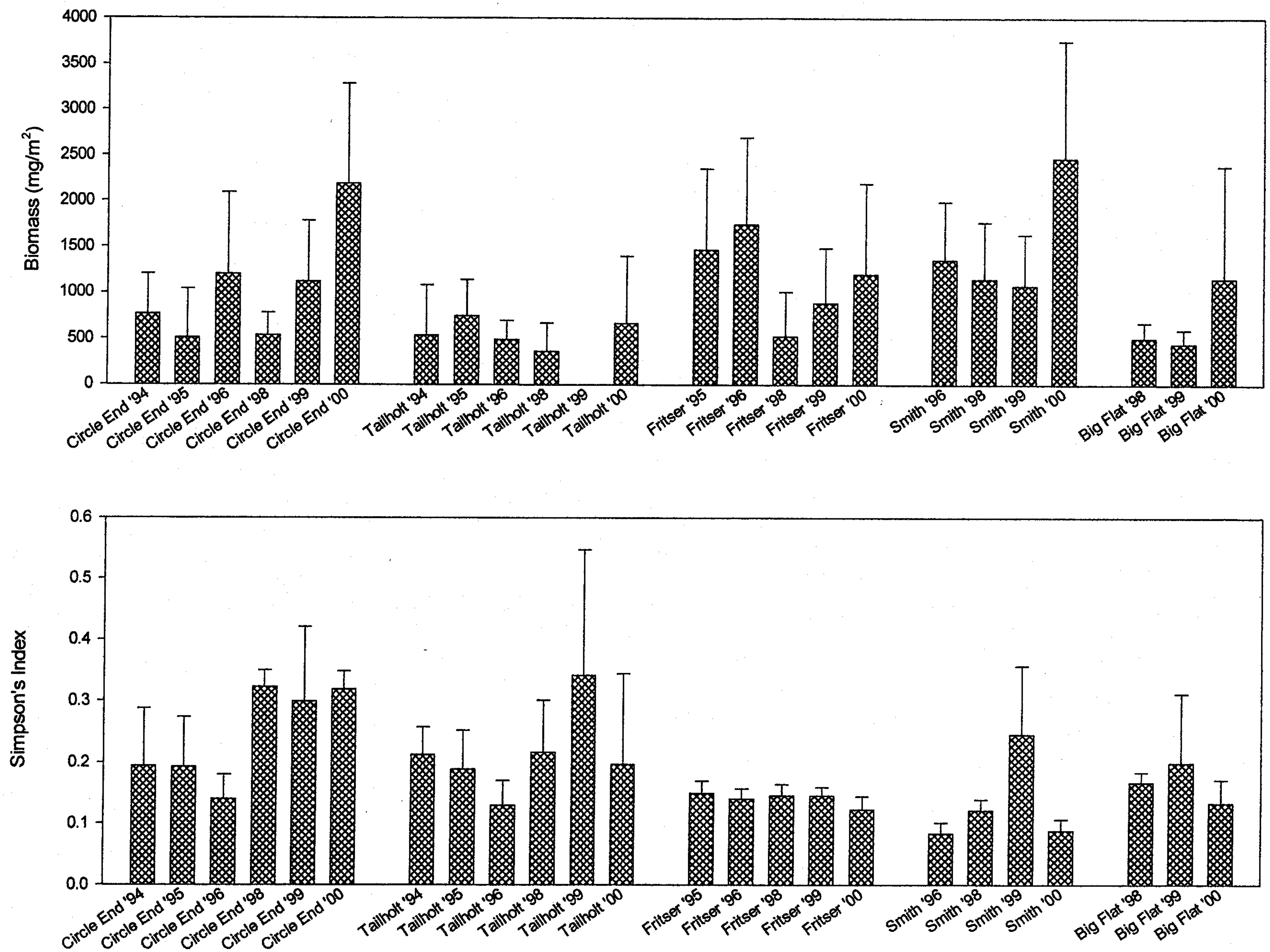

Figure 10. Mean macroinvertebrate biomass and Simpson's Index for each stream, 1994-2000. Error bars equal +1SD from the mean, n=5.

Table 8. 15 most relative macroinvertebrate taxa in the South Fork Salmon River tributaries, 2000. n=5.

Smith Creek	Mean	SD
Baetis spp.	15.73058	7.411229
Drunella doddsi	12.26375	4.905084
Caudatella spp.	9.886509	6.914746
Chironomidae	8.630194	2.425559
Oligochaeta	5.536092	6.007677
Hydropsychidae spp.	5.53017	1.91835
Ephemerellidae spp.	3.539314	3.48478
Arctopsyche grandis	3.500428	0.784627
Nemouridae spp.	3.312009	3.185556
Elmidae spp.	2.923853	0.87566
Ostracoda	2.655482	1.768057
Nematoda	2.214069	0.992637
Zapada spp.	1.745285	0.577517
Epeorus grandis	1.534053	1.506343
Capniidae spp.	1.495947	2.211604

Big Flat Creek	Mean	SD
Baetis spp.	21.52451	11.00493
Ephemerellidae spp.	16.03149	11.69756
Chironomidae	9.668952	6.474609
Neothremma spp.	7.158588	2.703054
Ostracoda	5.785373	1.894042
Nemouridae spp.	5.165675	4.620208
Zapada spp.	4.863502	3.781919
Elmidae spp.	4.59996	3.251532
Ampumixis spp.	4.481221	3.445827
Capniidae spp.	2.842315	3.55107
Micrasema spp.	1.898764	1.447984
Yoraperla brevis	1.689401	0.160758
Hydracarina	1.419564	0.296149
Nematoda	1.405477	1.415978
Simulium spp.	1.275239	1.563436

Tailholt Creek	Mean	SD
Baetis spp.	20.0298	10.49715
Oligochaeta	19.91395	26.94155
Chironomidae	15.10593	9.772775
Elmidae spp.	5.868786	3.76638
Glossosoma spp.	3.713434	6.617976
Ampumixis spp.	2.938976	2.429608
Ostracoda	2.911338	3.009734
Zapada spp.	2.764569	2.621766
Ephemerellidae spp.	2.401565	2.206925
Heterlimnius spp.	1.896996	1.363991
Capniidae spp.	1.783736	1.972323
Simulium spp.	1.524067	2.16657
Cinygmula spp.	1.314543	1.71624
Nematoda	1.171265	1.218673
Hydracarina	1.162296	0.850561

Circle End Creek	Mean	SD
Chironomidae	44.84229	7.385926
Baetis spp.	31.86357	7.674603
Simulium spp.	4.774369	4.992302
Ostracoda	2.242442	1.131173
Caudatella spp.	1.840909	1.211877
Micrasema spp.	1.735308	1.483911
Anagapetus spp.	1.148224	1.237113
Oligochaeta	1.099195	0.776986
Zapada spp.	1.029032	0.915985
Rhyacophila spp.	0.922818	0.483049
Hydracarina	0.765478	0.285415
Tricladida	0.676442	0.70808
Ampumixis spp.	0.54493	0.456946
Ceratopogonidae spp.	0.507898	0.505074
Capniidae spp.	0.507354	0.386385

Fritser Creek	Mean	SD
Baetis spp.	23.60348	6.402976
Caudatella spp.	12.51108	6.724144
Chironomidae	10.62778	4.085879
Ephemerellidae spp.	8.683993	6.618694
Nemouridae spp.	7.661967	5.454002
Zapada spp.	3.878311	1.771782
Epeorus grandis	3.398973	4.48661
Ostracoda	3.12367	2.515484
Simulium spp.	2.939767	3.497274
Hydracarina	1.914198	1.346717
Clinocera spp.	1.811192	1.4927
Dolophilodes spp.	1.699898	3.343839
Nematoda	1.353772	1.725673
Drunella spinifera	1.216094	1.517822
Heptageniidae spp.	1.051449	0.690402

(Table 8).

ACKNOWLEDGMENTS

Over the several years of our research many individuals have assisted in the field collection and laboratory processing of samples. During 2000 field personnel were: Jeffrey C. Barger, Adam R. Kleven, Jennye M. Minshall, Judy N. Minshall, James E. Morris, Cary D. Myler, Heather L. Ray, Christina D. Relyea, and Reuben J. Snyder. Laboratory personnel included: Annie Anderson, Jeffrey C. Barger, and Melanie Ovard. Quality assurance/quality control of the macroinvertebrate sorting was maintained by Judy N. Minshall. J.N. Minshall was also responsible for the characterization of organic matter. Taxonomic identification of the aquatic macroinvertebrates was conducted by H.L Ray and C. D. Relyea. GPS assistance was provided by J. E. Morris.

We especially thank Jim and Holly Akenson, resident managers of the University of Idaho's Taylor Ranch Field Station, for their hospitality in 2000. In the course of our research in the Frank Church "River of No Return" Wilderness Area numerous personnel from the U.S. Forest Service have befriended us or actively aided our research efforts, in particular we thank Dr. David Burns. In 2000 we especially thank Clem Pope and the U.S. Forest Service trail crew.

LITERATURE CITED

American Public Health Association. 1992. Standard methods for the examination of water and wastewater. APHA, New York.

Davis, J.C., G.W. Minshall, and C.T. Robinson. 2001. Monitoring wilderness stream ecosystems. Gen. Tech. Rep. RMRS-GTR-70. Ogden, UT: U. S . Department of Agriculture, Forest Service. Rocky Mountain Research Station. 137 p.

Merritt, R.W. and K.W. Cummins (eds). 1996. An introduction to the aquatic insects. 3rd edition. Kendall/Hunt Publishing Co., Dubuque, Iowa 862 p.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Forest Service General Technical Report INT-138 70 p.

Royer, T.V. and G.W. Minshall. 1996. Habitat and biotic conditions during 1995 in streams influenced by wildfire. Dept. Bio. Sci., Idaho State Univ. 46 p.

Royer, T.V., C.T. Robinson, and G.W. Minshall. 1995. Influence of wildfire on selected streams in the Payette National Forest. Dept. Bio. Sci., Idaho State Univ. 35 p.

Stednik, J.D. 1991. Wildland water quality sampling and analysis. Academic Press, New York.